FORAGE PRODUCTION

Ministry of Agriculture and Food
Ontario

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ACKNOWLEDGEMENTS

The authors would like to thank the Ontario Forage Crops Committee for the use of diagrams and tables that have previously appeared in the Forage section of the Field Crop Recommendations and D. Morris and S. Robinson for their valuable comments.

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CONTENTS

	Page
Introduction	3
Forage Species	3
Mixture Selection	8
Variety Selection	9
Forage Establishment	9
Fertility Management	12
Forage Winterkill	15
Weed Control in Forages	16
Forage Insects	18
Forage Diseases	21
Management for Stored Feed	23
References	28

INTRODUCTION

Forages, by definition, are whole plants used to feed livestock. Their history, as pasture, pre-dates that of man. Although we don't know when forages were first harvested as stored feed, we do know that as early as 50 A.D. Columella, a Roman, described in great detail the harvesting of hay crops and the necessity for proper storage.

Forages are Ontario's largest crop, utilizing about 36% of Ontario's improved land. They are an important component of crop rotations on many farms and their benefit has been demonstrated by numerous research trials and by farmer experience.

This publication will deal only with stored feeds. Pastures are covered in OMAF Publication 19, *Pasture Production.*

FORAGE SPECIES

There are two main groups of forage species: grasses and legumes.

LEGUMES

Legumes have the ability to use atmospheric nitrogen and the seed forms in a pod. Most legumes grown for forages have taproots and broad, compound leaves (composed of a number of leaflets) which are arranged alternately on the stem. New shoots originate from the crown of the plant and the growing point of each shoot is located at the top of the shoot. As a family, the legumes are higher in protein than the grasses.

If properly inoculated, legumes have the capacity to use atmospheric nitrogen, eliminating the need to apply it as commercial fertilizer. Legumes also supply a considerable amount of nitrogen to the grasses associated with them in the mixture.

ALFALFA

Alfalfa is the highest yielding perennial forage crop grown in Ontario. It produces more protein per unit area than other forage legumes and can be grown alone or in combination with a grass.

For high yields and persistence, alfalfa requires well-drained soil, a pH above 6.0, adequate fertility and the proper harvest management.

No consistent protein differences nor maturity differences have been identified among currently recommended alfalfa varieties. The stage of cutting is the most important determinant of protein level in the feed.

Alfalfa has a critical fall harvest period (see Winterkill section) which should be observed to avoid winterkill.

Figure 1. Alfalfa is the major forage species in Ontario.

BIRDS-FOOT TREFOIL

Trefoil is well adapted to steep or stony land that should not be worked, and is also adapted to soil where drainage is marginal for other legumes. It is a non-bloating legume and is best suited for permanent pasture situations. It has a lower yield and is harder to dry than alfalfa, which limits its usefulness as a hay crop. Although individual plants live for only a few years, stands of trefoil have remained productive for 10 or more years when allowed to go to seed.

Because trefoil seedlings are slow to start, it will usually take at least a year to get a satisfactory stand.

Trefoil, like alfalfa, has a critical fall harvest period, which is about 10 days earlier than alfalfa's at any given location.

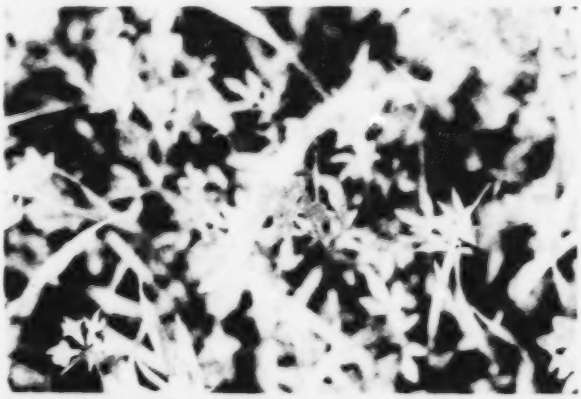

Figure 2. Birds-foot trefoil is seeded in long-term stands.

RED CLOVER

Red clover is a short-lived perennial. Yields are good the year after establishment, but are often quite low the following year, especially in southern Ontario. It can be grown in fields that are too wet or acid for alfalfa. When seeded in mixtures, red clover can suppress the establishment of other legumes. It is hard to dry, often resulting in "dusty or mouldy" hay. This limits its usefulness as hay, however, it can be stored as silage.

There are two general types of red clover grown in Ontario: double-cut or "medium" red clover and single-cut or "mammoth" red clover. Double-cut will flower in the seeding year, and regrowth after cutting is strong and vigorous. Single-cut is slower growing, has large stems, and matures about two weeks later than double-cut. Single-cut does not flower in the seeding year, or after the first cut in succeeding years.

Use of red clover as a plowdown or green manure has become an important practice on many farms. In general double-cut, because it produces more top growth, should be used for plowdown. In research trials on plowdown, there has been no advantage to using pedigree seed when compared to common seed lots.

When sown for plowdown, red clover is usually seeded with a companion spring cereal crop and then plowed under in late fall of the establishment year or early next spring. Red clover may also be broadcast or included in the spring application of nitrogen to winter wheat. The red clover stand should be allowed to grow as late as possible into the fall for maximum benefit.

Figure 3. Red Clover is suitable for short-term stands.

OTHER LEGUMES

White clover is a short-lived perennial which is used mainly in pastures. There are three general types of white clover — ladino, white Dutch and small wild white — with ladino being the most common one in Ontario. They are similar in appearance but differ in size, with wild white being the smallest and ladino the largest. All have stems that creep on the ground with branches that are erect or upward slanting.

Sweetclover is a biennial which grows slowly in the year of establishment and doesn't flower that year. In the spring of the second year it grows quickly to become a tall, coarse-stemmed plant. There are two types: white-flowered and yellow-flowered. White sweetclover is deeper rooted, taller and coarser which makes it more suitable for plowdown than for forage. The yellow-type is more palatable to livestock and attractive to bees.

Mouldy sweetclover hay may contain dicoumarol, which can prevent normal blood clotting and result in the death of livestock from bleeding.

Alsike is a perennial, although it is often treated as a biennial. It produces only one cut of hay per year.

GRASSES

Grasses have many long slender leaves which are borne on a stem. They have very fibrous roots which help bind the soil together thereby reducing erosion. Some grasses have rhizomes or underground stems which produce new shoots at each node. Grasses with rhizomes are capable of thickening up a stand. Grasses that do not have rhizomes are known as bunch grasses.

Grass species differ in their competitiveness with legumes and this will influence the grass-legume ratio of an established stand. Grasses such as orchard and the ryegrasses tend to be more competitive with alfalfa than timothy or bromegrass.

Grasses are lower in protein than legumes when cut at a similar stage of development.

TIMOTHY

Timothy is the most widely sown forage grass in Ontario, and is commonly grown in mixtures with alfalfa or trefoil. It is a bunchgrass with limited tillering ability, which makes it non-aggressive when sown with other species.

It is easy to establish in early spring or late summer and is adapted to heavier soils and variable drainage. Timothy is palatable and high yielding in first cut. Regrowth after first cut and mid-season production is not as high as that from either bromegrass or orchardgrass.

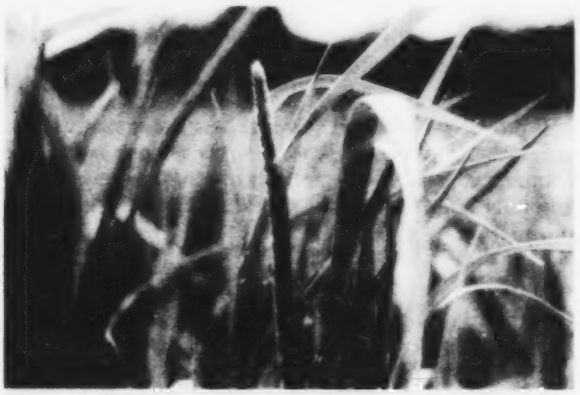

Figure 4. Timothy is the major forage grass in Ontario.

BROMEGRASS

Bromegrass is an earlier more aggressive grass than timothy. It has more regrowth in second cut because of its improved drought tolerance. It spreads by rhizomes and the stand can thicken over time.

Brome is palatable and tends to retain its nutritional value with increasing maturity better than most grasses. Its major drawback tends to be its large fluffy seed, which makes it difficult to seed through the small seed-box of drills. It does not establish well if it is either surface seeded or seeded deeper than 5 cm.

ORCHARDGRASS

Orchardgrass is earlier and much more aggressive than either timothy or brome. It is palatable when young, but loses palatability and digestibility faster than other grasses.

Orchardgrass is not as winter hardy as either timothy or brome and will not persist on wet soil. Its aggressive seedlings make orchardgrass easy to establish.

REED CANARYGRASS

Reed canarygrass has rhizomes and is best known for its ability to stand "wet feet" and do well in wet areas or on

poorly drained soil. It can however provide high yields on well-drained or even droughty soils. Reed canarygrass develops coarse stems and leaves and quickly loses palatability and digestibility if not cut at the boot stage.

Reed canarygrass is slow to establish, and is not competitive in the year of seeding.

In the past, livestock have performed poorly on reed canarygrass because of certain alkaloids it contained. All presently recommended varieties have reduced levels of the harmful alkaloids.

MEADOW FOXTAIL

Meadow foxtail is a long-lived perennial grass which resembles timothy in appearance and is suitable for intensive pasture management. It performs well on poorly drained soils, has very early spring growth, and matures very early. Midsummer production during periods of high temperature and drought may be low. Its seed is light, fluffy and hairy, and must be coated prior to seeding.

TALL FESCUE

Tall fescue is a coarse, leafy grass which is useful in long-term pastures and in erosion control. It is adapted to most soil types, tolerates imperfect drainage, withstands animal traffic well and maintains good feed quality into late fall. A seed-borne systemic fungus (an endophyte) has been linked to poor animal performance on tall fescue pasture. Endophyte-free seed is available and should be sown when tall fescue is seeded for pasture. Once introduced by infected seed, the fungus cannot be controlled in an established stand of tall fescue.

CREEPING RED FESCUE

Creeping red fescue is a dense, sod-forming grass which establishes and spreads vigorously on most soil types, including well-fertilized subsoils. Its solid root system and thick, fine top growth make creeping red fescue an excellent grass for streambank or grass waterway protection. It can also serve as a bottom grass in long-term pastures, and is noted for its extended growth period and retained nutritional value in the fall. Its low-growing habit makes it hard to cut, and unsuitable for hay.

MEADOW FESCUE

Meadow fescue is a hardy grass used in hay and pasture mixtures. It grows best on deep, fertile soils but will tolerate variable drainage and low fertility. Meadow fescue yields well during the summer and fall and maintains its feed quality later into the season than most grass species.

Meadow fescue is shorter and has finer leaves and a shallower root system than tall fescue and is not as persistent.

PERENNIAL RYEGRASS

Perennial ryegrass is a short-lived perennial that comes in turf-, pasture- and hay-adapted varieties. The pasture-adapted varieties tend to have finer leaves, smaller and more numerous tillers, and later maturity than the hay varieties.

Management of perennial ryegrass is different from that of timothy or brome. It is early and vigorous in the spring, and grows well into the fall, but is unproductive during the hot, dry summer months. Winterkilling is promoted by excessive top growth going into the winter. Thus ryegrass may kill in alfalfa mixtures not cut after the end of August.

Because the more recently introduced pasture- and hay-adapted varieties have not yet been shown to have adequate winterhardiness, no varieties are yet recommended for use in Ontario.

Figure 5. Perennial ryegrass has variable winterhardiness under Ontario conditions.

ANNUAL RYE GRASS

Annual ryegrass is a rapidly growing bunch grass that is adapted to a wide range of soil conditions. It is a useful species for mid- to late-season production but does poorly under high temperature conditions. Two types of ryegrass are available and they differ remarkably in their growth habit. The Italian ryegrasses are short-lived perennials, but under Ontario winter conditions behave like an annual. In the seeding year, Italian ryegrass remains vegetative, producing a lush leafy growth that usually doesn't grow taller than 40 cm. The Westerwold-type is a true annual and grows to 40-80 cm high, making it suitable for pastures or hay crops. Feed quality decreases rapidly after heading.

BLUEGRASSES

In Ontario, two common bluegrasses, Canada and Kentucky, grow on about one million hectares of permanent pasture land. In southern Ontario, the shallow-rooted bluegrasses produce lush, palatable growth during the spring, but are unproductive during the dry, hot summer.

When properly fertilized and managed, bluegrass production can be markedly improved, especially in the cooler climate of northern Ontario. In pastures, they serve as a bottom grass that controls weed invasion, withstands close grazing and tramping, and fills in when other species thin out.

TABLE 1. Characteristics of Forage Species Grown in Ontario

Species	Suitable For	Persistence, Years	Strengths	Cautions
Alfalfa	Stored Feed	3-4 S. Ont. 1-4N. Ont.	Excellent quality Excellent yield	May cause bloat Poor persistence under grazing Low tolerance to acid or variably drained soil Needs fall rest period
Birds-foot Trefoil	Stored Feed Pasture	5+ may reseed	High quality No bloat hazard Good tolerance to acid and variably drained soil	Slow to establish Slow spring growth and regrowth Needs fall rest period
Red Clover	Stored Feed Plowdown Pasture	1-2 S. Ont. 2-3 S. Ont.	Excellent first year yield Easy to establish High quality Good tolerance to acid or variably drained soil	May cause bloat Stand thins rapidly May cause temporary infertility in grazing sheep Very competitive, especially with other legumes
White Clover	Pasture	5+	Excellent quality and palatability Good tolerance to close grazing	May cause bloat Low drought tolerance
Alsike	Stored Feed Pasture	2-3 (may reseed)	Very good tolerance to wet, acid soils Good quality	Not consistent production from year to year May lower yields when added to mixtures May cause bloat
Sweetclover	Plowdown Stored Feed	2	Excellent soil builder Opens up subsoil Excellent "bee" pasture	Low palatability unless harvested early Coumarin content in older varieties causes feeding difficulties
Timothy	Stored Feed	5+	Easy to establish Good tolerance to variable drainage Seed is inexpensive	Poor summer production Poor persistence of late varieties under 3-cut harvest system
Bromegrass	Stored Feed Pasture	5+	Excellent spring / fall yield Good regrowth Retains quality with maturity	Large seed size creates seeding problems More aggressive than timothy
Orchardgrass	Pasture Stored Feed	5	Very early pasture Excellent regrowth Good drought tolerance Good tolerance to close grazing Very responsive to N	Rapidly loses quality and palatability with maturity Very competitive with other species Poor tolerance to variable drainage and icing
Reed Canarygrass	Stored Feed Pasture	5+	Excellent yield on both variably drained and dry soils Good regrowth	May be slow to establish Rapidly loses quality and palatability with maturity

TABLE 1. Characteristics of Forage Species Grown in Ontario (continued)

Species	Suitable For	Persistence, Years	Strengths	Cautions
Meadow Foxtail	Pasture	5+	Easy to establish Excellent, very early yield Excellent tolerance to variable drained soil	Need to use coated seed Very competitive with other species Low drought tolerance
Tall Fescue	Stored Feed Pasture Grass Waterways	5+	High yield Good summer growth Good feed quality in fall Good tolerance to acid soils	Low palatability Need endophyte-free seed Coarse leaves
Creeping Red Fescue	Pasture Grass Waterways	5+	Good feed quality in fall Easy to establish Good tolerance to close grazing and to acid soils Good regrowth Excellent soil builder	Low seasonal yield Low palatability
Meadow Fescue	Stored Feed Pasture	5	Good summer yield Good feed quality in fall Fine leaves attractive to livestock Good tolerance to acid soils	Less persistent and lower yielding than tall fescue Slow to establish
Perennial Ryegrass	Pasture Stored Feed	2-3 S. Ont.	Excellent quality and palatability Establishes very quickly Good regrowth if moisture is adequate Good tolerance to close grazing	Poor drought and heat tolerance Poor tolerance to variably drained soils Variable persistence
Annual Ryegrass	Pasture Stored Feed	1	Excellent quality Establishes quickly Good fall yield Good tolerance to close grazing	Poor drought and heat tolerance Very competitive with other species
Kentucky Bluegrass	Pasture Grass Waterways	5+	Good quality and palatability Good tolerance to close grazing	Poor summer production Very slow to establish Low seasonal yield

MIXTURE SELECTION

Soil conditions are often important in determining which species are suitable in a mixture. Usually the legumes are selected before the grasses, because they are often more sensitive to drainage and pH. Soil conditions such as steepness or stoniness may make it desirable to seed a legume which has long-term persistence. Consult the section on forage species for more information on legume tolerance to various soil conditions (see Figure 6, Soil Drainage Requirements of Forage Species).

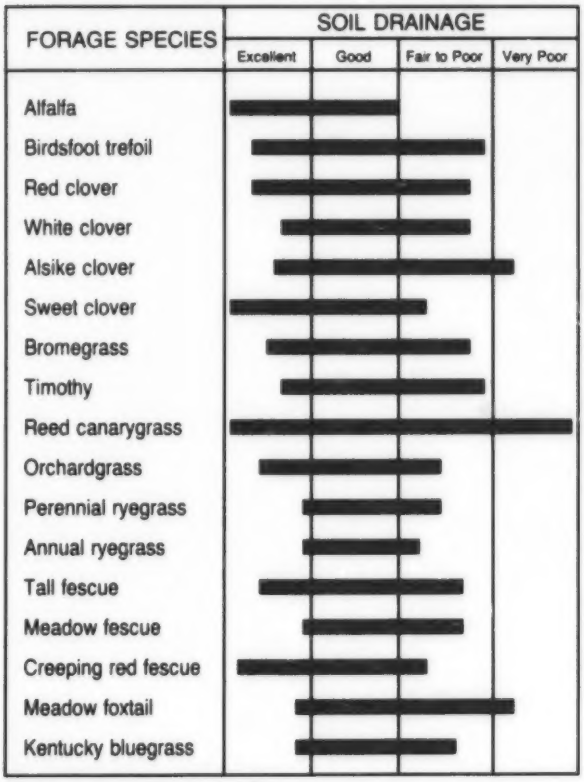

Figure 6. Soil Drainage Requirements of Forage Species.

Legumes are usually grown in a mixture with one or more grasses, unless there is a good reason to grow them in pure stands. Pure stands can lead to several problems — weedier stands, complete loss of feed supply if winterkill is severe, slower drying in the windrow, more lodging, and under some conditions, less palatable feed. While inclusion of grass does not always increase yield, it may improve yield stability as the stand gets older. The major advantage of a pure legume stand is that the protein level of the feed will likely be higher and will vary little from cut to cut.

When selecting the grass, a major consideration should be the maturity of the grass. If early heading species such as orchardgrass and reed canarygrass are used, then harvesting must be early, or quality and palatability suffer. If harvesting will be later, a later maturing grass such as timothy is more suitable. Since there is a range in maturity among different varieties within many species, variety maturity may also need to be considered.

Consider the ratio of grass to legume desired in the mixture. A range in grass seeding rates is given in Table 2. If more grass is desired and a lower protein level is acceptable (e.g., beef cow-calf), use the higher grass seeding rates. Higher grass rates tend to reduce weed invasions, particularly by dandelions. If conditions for legume survival are marginal, use higher grass rates for stand insurance. More aggressive grasses (such as orchardgrass) will give more grass in the mixture than less aggressive species even when similar seeding rates are used.

For a number of years, timothy has been the grass of choice when grown in mixtures with alfalfa, red clover and trefoil in Ontario. This reflects the ease of seeding, relatively low seed cost, lack of crowding of the legume, and later maturity of timothy, which make it easy to manage in mixtures. In specific situations, the other grasses can give better results than timothy, but often require somewhat different management.

Figure 7. Orchardgrass (right) provides more midsummer grass in alfalfa mixtures than timothy (left).

Timothy does not crowd alfalfa, in fact, under a three-cut system, it often declines in the stand and provides very little forage in second or third cuts. If a strong grass component is desired in the mixture, particularly in second and third cuts, then orchardgrass should be used; it is an aggressive grass and will crowd alfalfa as the stand gets older. Bromegrass and reed canarygrass are intermediate in aggressiveness (between timothy and orchardgrass).

Management can affect the competitiveness of grasses with legumes. Late harvest, when grasses are in bloom, favours the grasses relative to the legumes. This is particularly true with reed canarygrass; cut at the boot stage, this species does not crowd legumes. But if allowed to fully head, it rapidly takes over the stand. It is particularly important in trefoil mixtures, if bromegrass or reed canarygrass are used, to harvest promptly at the grass boot stage. If this is not possible or practical, then timothy is a more suitable grass.

Grasses are not usually grown in pure stands, because they are low yielding without heavy applications of nitrogen (see Forage Fertility section). Even with adequate fertility, some grass species produce low yields under hot, dry mid-summer conditions. However, if soil conditions (e.g., drainage) or other factors make mixtures with legumes impractical, pure grass stands can be very productive with proper fertility programs and species selection.

For stored feed, usually only one grass species is recommended. When two or three different species are used

together, cutting at the proper stage of maturity for all grasses may be impossible. Timothy is often included with slow-establishing grasses such as bromegrass and reed canarygrass.

TABLE 2. Forage Mixtures and Seeding Rates for Stored Feed

Conditions of Use	Legume(s) (kg/ha)	Grass(es) (kg/ha)
Well-drained soils; early first cut, high protein silage	alfalfa (11-13)	none
Well-drained soils; stored as silage or hay; protein varying with amount of grass. Grass for stand insurance, easier curing and weed suppression	alfalfa (9-13)	timothy (1-4) or bromegrass (6-9) or orchardgrass (1-4) or reed canarygrass (4-6)
Moderate to well-drained soils; higher grass content desired; possibly pastured after first cut.	alfalfa (9) + white clover (1-2)	timothy (2-4) + bromegrass (4-6)
Good to variably drained soils; lower pH; short-term stands	red clover (7-9)	timothy (3-6)
Variable to poor drainage; or lower pH; or long-term stands on stony, sloping land	bird's-foot trefoil (9)	timothy (2-4) or bromegrass (4-6) or reed canarygrass (4-6)
Variable or poor drainage; long-term pure grass stand	none	timothy (8) or bromegrass (10) or reed canarygrass (10)

For additional information on specific forage mixtures, consult the current issue of OMAF Publication 296, *Field Crop Recommendations.*

VARIETY SELECTION

Information on the performance of all recommended forage varieties is published each year in either OMAF Publication 296, *Field Crop Recommendations,* or in the OMAF Publication 296 Supplement. Reports include yield performance, resistance to significant diseases, maturity and regrowth rate. Once the species and mixture have been selected, this information should be consulted in selecting suitable varieties.

The use of pedigree seed, rather than brands or common seed, is strongly recommended. Only by planting varieties is it possible to know in advance whether the seed you plant will provide the yield, persistence, disease resistance and maturity that is required for your specific fields and farm operation.

FORAGE ESTABLISHMENT

FIELD AND SEEDBED PREPARATION

When selecting a field, consider whether it is suitable for the mixture you wish to plant. If there are limitations such as low pH, poor drainage or weed problems such as quackgrass, these should be corrected prior to seeding.

On silt loam and clay loam soils forage establishment is most reliable when the field has been fall plowed. Freezing and thawing action on these soils results in easier preparation of a fine seedbed the following spring. On heavier soils plowed in the spring, it can be difficult to produce a fine seedbed without excessive tillage.

Sandy loam and loam soils can usually be spring plowed without encountering problems in seedbed preparation. However, during dry springs the soil must be worked and packed quickly to avoid excessive moisture loss.

On land susceptible to erosion, reduced tillage systems that leave some crop residue on or near the surface are desirable. However, too much crop residue may interfere with proper seed placement.

Secondary tillage in the spring before planting is important for several reasons:

1. To produce a firm, level seedbed that allows good control of seeding depth.
2. To produce a fine seedbed which permits good soil to seed contact. Lumpy soils often result in poor emergence, because the soil dries out too fast or the young seedlings can not emerge around the lumps.

3. To produce a smooth surface for the harvesting operations.

Heavier soils that are worked too fine may crust, thereby reducing emergence, while increasing water erosion due to poor water infiltration.

On sandy loam soils, there is a tendency to produce a fluffy seedbed, particularly when using a disc. In such situations, it can be very difficult to control seeding depth and packing may be necessary before seeding.

SEEDING EQUIPMENT

There are a number of different types of seeding equipment available and being successfully used by farmers.

GRAIN DRILL

The grain drill with a grass seed attachment is a very satisfactory method of seeding forages. The standard grass seed box will handle legume seeds and smaller grass seeds such as timothy and reed canarygrass. Some drills have an additional seed box designed to seed coarser grasses such as bromegrass and orchardgrass which do not flow well through the standard box.

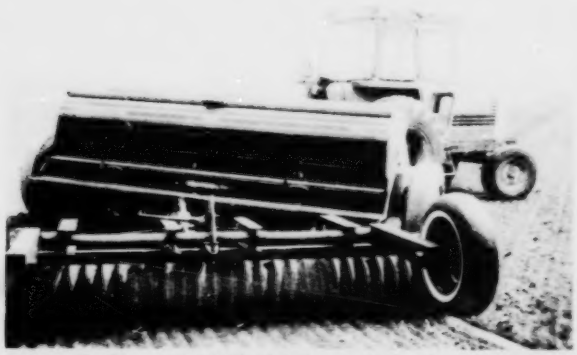

Figure 8. The grain drill with drop-pipes, along with packing, is a good forage seeding method.

Most newer drills have drop pipes attached to the grass seed box. Align the drop pipes so that seed is dropped in a row over the fertilizer placed by the disc opener. The seed should be dropped 25-35 cm behind the disc opener to allow some soil to cover the fertilizer band before the seed is dropped. This placement also ensures that the seed is not planted too deep (see Figure 9).

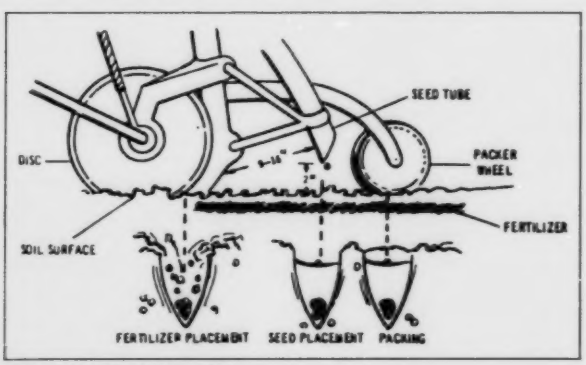

Figure 9. Band Seeding.

Packing the soil after planting can result in a much more even germination, particularly during dry springs. Press wheels, available on newer drills, help cover the forage seeds and firm the soil around the seed.

If press wheels are not available, very satisfactory results can be obtained by pulling a packer or rubber tire roller behind the drill to firm the soil. Do not use a packer if the soil is wet, particularly on clay loam soils, where crusting can be a problem.

PACKER SEEDERS

Packer seeders (e.g., Brillion) can be successfully used to seed forages and are equipped with both fine and coarse seed boxes. The first roller firms, levels and grooves the soil and the seed is then dropped on this surface. The second roller covers the seed with soil and firms it around the seed. This type of seeder does an excellent job of controlling seed depth and firming the seedbed. It does not apply fertilizer and thus it is not possible to get the starter effect achieved with the grain drill-band seeding method. This is a disadvantage mainly at low and medium soil phosphorus levels.

BROADCAST SEEDERS

Broadcast seeders are also used to seed forages. Their main advantage is speed of seeding. There are two types of broadcast seeders and with both, control of seeding depth is a problem. Packing is necessary to cover the seed.

Seeders that use spinners can give uneven distribution, particularly under windy conditions or with seed mixtures containing light and heavy seeds. This seeding method usually results in inferior stands and is not recommended.

Air-flow boom seeders overcome the problems of wind and seed segregation while still permitting very rapid seeding.

SEEDING WITH A COMPANION CROP

Much of the forage acreage in Ontario is seeded under a companion grain crop. This system of seeding provides a grain crop and a crop of straw, while the forage crop is being established. The companion crop suppresses annual grass weeds and will give fairly rapid protection from erosion on rolling land.

The companion crop competes with the forages for moisture, light and fertility and if any of these items are deficient, the forage seeding will suffer before the grain crop does.

Lodging of the companion crop due to excess nitrogen can be a real threat to forage establishment. One should recognize that the primary purpose of the seeding is to establish the forage, and grain and straw production are of secondary importance. Follow these guidelines:

1. Oats are the best companion crop followed in order of compatibility by mixed grain, 6-row barley, spring wheat, 2-row barley, winter wheat and winter rye. (Alfalfa or trefoil mixtures seeded under winter wheat or winter rye are often failures.)

2. As a general rule, select the strongest strawed, shortest and earliest grain variety in any species for the least competition.
3. Reduce the seeding rate to 60 to 70 kg/ha with spring grains. The seeding rate of winter cereals can be reduced, but increased tillering will often offset the effect of reduced seeding rates.
4. Reduce the nitrogen fertilizer or manure rate to minimize the risk of a dense grain crop and/or lodging. Under most conditions, do not apply more than 15 kg/ha of nitrogen on spring grains, or 40 kg/ha on winter grains.

REMOVAL OF COMPANION CROP FOR SILAGE

Some of the problems associated with seeding under grain can be eliminated by harvesting the grain crop as silage. For dairy cattle, cereals should be harvested at the late boot stage to obtain feed of good quality. For beef cattle, harvest can be delayed to the fully headed stage.

Harvesting the companion crop as silage allows weed suppression and erosion control, but the grain is removed before it lodges, or competes excessively for light and moisture. In this situation, both the seeding rate of the cereals and the nitrogen application may be the normal rate in order to increase the silage yield. With reasonable soil moisture following harvest, it is quite possible to also obtain a cut of forage in late August in areas with 2600 heat units or more.

Figure 10. Harvesting the companion crop as silage eliminates the hazard of grain lodging.

DIRECT SEEDING

Seeding forages without a companion crop removes the potential threat to establishment from the grain crop. Under good management, direct-seeded forage stands are often thicker and more uniform. This is particularly true of forage species such as birds-foot trefoil, alfalfa and reed canarygrass which do not tolerate heavy shade. Since a grain crop is not competing for soil moisture, direct seedings are less affected by June or July droughts.

Early spring direct seedings can be expected to give one or two cuts of forage in the seeding year, yielding 50 to 60% of an established stand. Direct-seeded forages are useful when the harvested forage acreage must be increased on short notice to compensate for winterkill or increased forage requirements. Direct seedings have been most popular in Ontario:

- on silt loam, loam and sandy loam soils;
- with trefoil- or alfalfa-based mixtures;
- on dairy farms where nitrogen buildup from livestock manure frequently results in cereal grain lodging;
- where a cash crop of winter wheat provides straw for bedding, and grain corn provides the bulk of the grain requirements.

Direct seedings have not met with success on all farms. Weed competition is a greater problem with direct seeding than with underseeding; this problem is most likely to limit the success of direct seedings (see Weed Control Section).

In the year of seeding the root system of forage crops are shallow and therefore more vulnerable than established stands to drought. Droughts can reduce production to one cut rather than two, but do not usually reduce the stand.

Direct seedings on heavier clay loam soils require more skillful seedbed preparation and seeding. Clay soils, particularly where the seedbed is somewhat lumpy, are more vulnerable to dry conditions during germination, thereby reducing establishment. They also are more vulnerable to crusting and seedling emergence problems if heavy rains follow seeding.

SEEDING

The preferred seeding time for forages is early spring, regardless of whether the crop is direct-seeded or under a companion crop.

Seed as early as a seedbed can be prepared to increase the chances of adequate and frequent moisture during the critical germination period.

Recommended seeding rates are given in Table 2. These are rates suitable for average to good conditions. Under good management and favourable conditions for establishment, these rates may be reduced by 25%. Do not expect very high seeding rates to compensate for poor management (a rough seedbed, heavy companion crop, etc.).

The number of seeds per kilogram for various forage species is listed in Table 3.

TABLE 3. Seeds Per Unit of Various Forage Species

Crop	Seeds per kg
Alfalfa	440,000
Red Clover	605,000
White Clover	1,760,000
Bird's-foot Trefoil	935,000
Sweet Clover	572,000
Alsike	1,540,000
Timothy	2,706,000
Orchardgrass	1,439,000
Bromegrass	300,000
Meadow and Tall Fescue	506,000
Perennial Ryegrass	500,000
Reed Canarygrass	1,173,000
Bluegrass	4,790,000

A 1 cm depth of seeding is considered ideal. Emergence drops rapidly if seed is planted over 2 cm deep. Legume seed on the soil surface may establish if moisture conditions following seeding are ideal. Success of surface seeding is much greater with late March-early April seedings than in late April or May.

SUMMER SEEDING

In most of southern Ontario it is possible to obtain forage stands with a summer seeding in August.

A summer seeding can overcome some of the weed problems encountered in spring seedings. The annual grasses and many of the problem broadleaves either do not grow or are not a problem. If a forage stand is found to be too thin, it can quickly be replaced by a summer seeding following winter or spring cereal harvest.

Experience to date with summer seedings has shown that the greatest risk of failure comes from:

1. late seeding of forages;
2. competition from volunteer cereals.

Figure 11. Summer-seeded alfalfa plants, large enough to overwinter.

In areas with 2500 heat units or less, summer seeding after cereal harvest is not practical because seeding should be completed by August 10th and cereal harvest may not be complete by then. In areas with over 2500 heat units, aim for forage seeding by August 10, with August 20 as the cutoff date. In areas with 2900 or more heat units, seeding as late as August 30 is possible, although August 15-20 is preferable. Seeding later than these dates will result in small legume plants that are more susceptible to winter heaving. Even if these plants survive, they will be slower starting and lower yielding in the first cut and only two cuts may be possible.

Always pack summer seedings after seeding to bring soil moisture up to the seed zone. There is some risk in seeding into very dry soil at the cutoff seeding date – if it does not rain for a week or two, emergence will be delayed and one will be faced with the same problems encountered with seeding late.

Volunteer grain, because it may be thick and competitive, can be a serious problem in summer seedings. Oats or barley will winterkill in November, but winter wheat will be present until the first cut the following year. To reduce the problem of volunteer cereals, either plow after harvest to bury the grain or cultivate lightly right after harvest to stimulate germination, and work the field again prior to seeding the forage. There are herbicides that will kill volunteer cereals but forage grasses in the mixture will also be killed.

INOCULATION

For normal growth, all legumes must have nitrogen-producing nodules on their root systems. These nodules are produced by rhizobium bacteria. When a legume species has routinely been grown in a field as part of the rotation, these bacteria are present in the soil and will automatically result in good nodulation.

If a legume is being planted for the first time in a field, the seed must be inoculated with the proper strain of rhizobium bacteria before planting. Each legume species (alfalfa, clover, trefoil) requires a specific strain of rhizobia. The cost of the rhizobia is low in comparison to the cost of seed. Thus if one is in doubt about the presence of rhizobia in the soil, the seed should be inoculated. Since inoculant must be alive, check the expiry date on inoculant and follow handling instructions.

Pre-inoculated seed (with or without a coating) is satisfactory, provided that the inoculant is applied in the current season.

FERTILITY MANAGEMENT

Forage crops have traditionally received less fertilizer than grain crops, yet high-yielding forage crops remove much more phosphorus and potash than grain crops do. Adequate fertility is essential to maintain the legume component in the stand and to prevent forage yields from tapering off as the stand gets older.

SOIL pH

There is a wide range in pH requirements of different forage species (see Figure 3 for the pH requirement of the various species). The grasses and alsike clover grow reasonably well at pH levels in the 5 to 5.5 range. Alfalfa and sweet clover must have a pH of 6.0 or higher to perform well. Raising the soil pH above 6.0 results in more efficient use of fertilizer and soil nutrients by all species.

When alfalfa or sweet clover are to be grown, a soil pH below 6.0 must be raised to a target level of 6.5 by adding limestone; use soil test to determine the type and rate of limestone that is required. If magnesium levels are low, use dolomitic limestone rather than calcitic. Apply limestone

at least 6 months prior to seeding, to allow time for limestone to raise the pH.

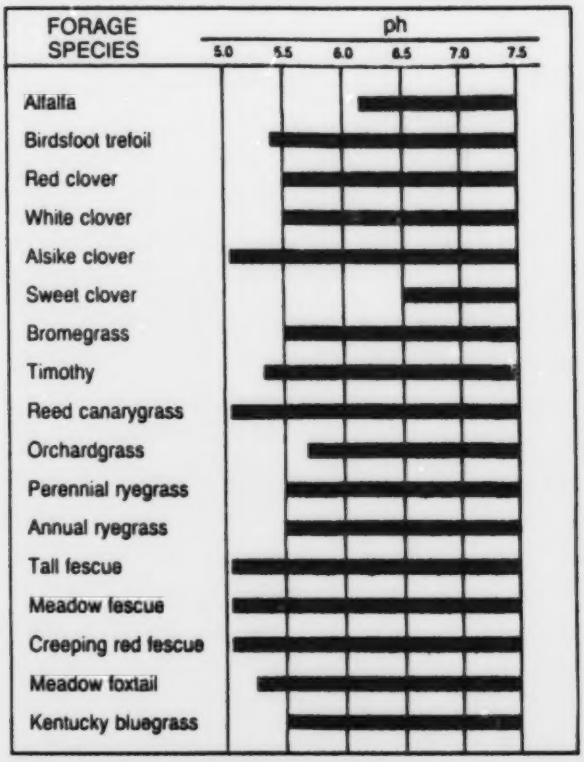

Figure 12. pH Range for Forage Species.

MANURE

Manure is low in phosphorus, but an excellent source of nitrogen, potassium and micronutrients. It is well suited to grass stands, which can make good use of the nitrogen in manure.

Manure can be used on legume or legume-grass stands with certain precautions:

1. The nitrogen component in the manure is wasted on legume stands, since legumes already receive all the nitrogen they require through nodules on their roots. However, legumes will use the other nutrients in the manure.
2. On fields with a higher percentage of grass, or with aggressive species such as orchardgrass, the nitrogen in manure may stimulate the grass growth and crowd out the legume component in the mixture.
3. Do not spread manure on forage legumes when there is snow cover. Ice can form, both under manure and in the wheel tracks, and kill legumes, particularly alfalfa.
4. Solid manure spread at any time of year must be well broken up by the spreader beater bars, or clods of manure will smother plants.
5. Spreading manure when soil is wet results in soil compaction and mechanical injury to alfalfa crowns.
6. If liquid manure is spread on legume stands, it should be applied immediately after harvest, to prevent burning of the regrowth.

Figure 13. Poorly spread manure on alfalfa mixtures causes smothering.

FERTILIZER

The amount of fertilizer to apply to legume forage stands should be determined by a soil test. Fertilizer rates suggested from the soil test are designed to produce the highest economic yields. Because forages can remove large amounts of nutrients, annual testing is advisable. If the only soil test available is from a previous non-forage crop, consult the Forage section of OMAF Publication 296, *Field Crop Recommendations,* for assistance in selecting a fertilizer rate.

Fertilizer Use (At Seeding)

The most appropriate rate and analysis of fertilizer to use when seeding is best determined by a soil test. When direct seeding, no nitrogen is required at seeding. Up to 15 kg/ha of nitrogen may be used when seeding with a companion crop.

Phosphorus is the most important nutrient for developing a good root system and promoting rapid early growth. It is essential for good stands when soil phosphate levels are in the low range. Forage seedlings show the greatest response to phosphorus when the fertilizer is drilled in rather than broadcast, and the forage seed is banded above the fertilizer band (see Seeding Equipment, Grain Drill section).

While potash is required in high amounts by established stands, requirements at seeding are quite low. Potash needs at seeding can usually be met with 50 kg or less of potash per hectare which can be applied with the required nitrogen and phosphate at seeding. Where high rates of potash are being applied at seeding on low testing soils, most of it should be broadcast prior to seeding.

Fertilizer Use (Less than 35% Legume)

Phosphorus and potassium requirements should be determined by a soil test. Grasses respond to these nutrients and remove amounts similar to legumes, provided growth is not limited by a shortage of nitrogen.

Grasses require large amounts of nitrogen to give equivalent yields to those from grass-legume mixtures. Thus it may be desirable when legumes thin out to reseed the field. In situations where it is difficult to keep legumes

in the stand, it can be profitable to grow grass stands and fertilize with nitrogen. The grass stand should be relatively thick and composed of productive species such as bromegrass, orchardgrass, reed canarygrass or timothy. Response to midsummer nitrogen application is higher with orchardgrass and reed canarygrass, because they tolerate summer heat and drought best. Response to nitrogen will be disappointing if soil phosphorus or potassium requirements are not met.

As well as increasing yield, nitrogen rates of over 50 kg/ha will result in increased protein level in grasses.

For the most economical rates of nitrogen on grass, based on the value of hay and cost of nitrogen, consult OMAF Publication 296, *Field Crop Recommendations.*

Fertilizer Use (More than 35% Legume)

Stands composed of 50% or more legumes do not show a yield response to nitrogen. Where legume content has dropped to between 35 and 50% of the stand, 60 kg/ha of nitrogen is recommended. This application will speed the loss of legumes by promoting grass competition, but it will also increase the forage yield.

Potassium is particularly important for alfalfa, because it not only influences yield, but also persistence. When alfalfa lacks potassium, it is more likely to winterkill.

Figure 14. Potassium deficiency symptoms on alfalfa.

Yields of 11 tonnes/hectare (5 tons/acre) of an alfalfa-grass mixture will probably remove 250 to 300 kg/ha of potassium. Many clay loam soils are capable of meeting this demand without significant drops in fertility. However, sandy loam and loam soils cannot meet this nutrient demand, and potassium levels will drop significantly over three or four years. Soil with a low potassium test will result in thinning of an alfalfa stand. Monitoring fertility changes through regular soil testing is important to prevent a nutrient drop which will result in yield and stand decline. Readings below 2% potassium in a feed analysis also indicate the alfalfa plant is not obtaining sufficient potassium for good winter hardiness.

Potassium fertilizer is often applied shortly after the final cut. This timing ensures that the fertilizer will be available to permit storage of food reserves necessary for good winter survival. Provided that potassium is applied at soil test rates, application after the first or second cut should be equally effective.

Normally there is very little yield advantage to splitting the fertilizer into three applications (i.e. one after each cut). The recommended rates are designed to provide enough nutrients for a full season's production. The extra trips increase the total cost of application and possibly increase crown injury. Two applications per year rather than one may be desirable on very sandy soils which have low exchange capacities, or when 400 kg/ha or more of potassium are required per year

High applications of potassium tend to lower the magnesium content of forages. This often has no impact on alfalfa yield, but may influence the mineral-feeding program that is required (particularly on dairy farms). A feed analysis will indicate whether adjustments in magnesium in the mineral ration are needed.

MICRONUTRIENTS

Boron is the only micronutrient which is frequently deficient in Ontario forages. The deficiency is most common in the counties between Simcoe and Hastings, but also occurs on sandy loams and some loams in other parts of Ontario. This deficiency mainly affects alfalfa, but it can also appear on red and white clover and trefoil. Deficiencies usually show up in the second or third cut under dry soil conditions, particularly on high pH soils.

Figure 15. A close up of boron deficiency symptoms on alfalfa.

Figure 16. Field appearance of boron deficiency.

Boron deficiency causes a yellowing or reddening of the top leaves of alfalfa. Plants are stunted and the stem length

between leaves is shortened. Flowers do not develop and often the growing point dies. Yield can be greatly reduced, because fewer cuts can be taken. Since leafhopper injury can be very similar to boron deficiency, obtain assistance in diagnosing this problem.

Boron deficiency can be corrected by applying 1 or 2 kg/ha of actual boron per year. Many fertilizer outlets will blend boron with the phosphate-potassium fertilizer on request. Apply boron to established stands, rather than at seeding. See OMAF Factsheet, *Boron Requirements for Alfalfa*, Agdex 121/531.

Sulphur deficiency has only been diagnosed in northern and northwestern Ontario. This deficiency causes a pale green to yellowish-green colour in newly developing leaves. The leaf veins appear distinctively lighter in colour. This deficiency show up when nutrients and moisture favour rapid plant growth.

Sulphur deficiency can be corrected by the application of 25 kg/ha of actual sulphur, using gypsum as the sulphur source.

FORAGE WINTERKILL

Winterkill of forage stands can cause serious problems on livestock farms. It can result in lower quality feed, shortages of feed, disruption of the rotation and additional cost of reseeding lost stands.

Winterkill is often due to a combination of direct and indirect causes. Direct causes are things such as: smothering due to flooding or ice sheet formation; heaving caused by freezing and thawing and inadequate drainage; and root injury due to low temperature. Indirect causes, such as low fertility, poor cutting management, disease or insect attacks, place forage plants under stress and make them even more susceptible to winterkilling by direct causes. Often the indirect causes of winterkill are more easily controlled by management than are the direct causes. Good forage management seeks to reduce or eliminate the indirect causes of winterkill.

Some forage species are hardier than others. The grasses timothy, reed canarygrass, bluegrass and bromegrass rarely winterkill. Thus their use in mixtures gives stand insurance. Orchardgrass and perennial ryegrass may be killed by icing or low temperatures.

Figure 17. Poor drainage and icing cause alfalfa winterkill.

The legumes birds-foot trefoil, red clover, wild white clover and alsike will tolerate more adverse winter conditions than will alfalfa or ladino clover. Much of the concern over winterkill centers around alfalfa, because it is the basis of most stored feed mixtures in Ontario and is frequently winterkilled. There are a number of management practices that will significantly reduce alfalfa winterkill:

Figure 18. Leaving fall regrowth traps snow and provides insulation against low temperatures.

Figure 19. Inadequate drainage leads to alfalfa heaving.

1. Poor or inadequate drainage is the major cause of alfalfa winterkill. Poor drainage leads to smothering under ice sheets and heaving under freezing-thawing conditions. Ice, being a very poor insulator compared to snow, also leads to low temperature injury.
2. Satisfactory fertility levels are important to produce healthy alfalfa plants. Adequate soil potassium levels allow alfalfa to store sufficient carbohydrates in the roots to resist low temperature injury and act as the energy source for vigourous spring growth. Potassium levels in soil should be tested regularly (see Fertility Manage-

ment section). Boron deficiency can lead to stunted alfalfa growth during midsummer dry spells and thus weaker plants going into winter.

3. Soil pH level should be at least 6.1, with a target level of 6.5 or higher. Low pH results in weak, nitrogen-deficient plants.
4. Plant only recommended alfalfa varieties because these varieties have shown adequate winterhardiness in provincial trials. Select varieties with a high level of resistance to diseases, particularly wilt diseases. Aim to reduce mechanical injury and root rots by staying off the field with heavy machinery when the soil is wet.
5. Winter survival can be reduced by heavy feeding by leafhoppers on alfalfa. In areas where leafhopper outbreaks in July or August are frequent, monitor this insect and control with insecticide when necessary.
6. Leave the fall regrowth in the field, rather than harvesting it in October, to trap the snow. This provides insulation and reduces injury from both low temperature and heaving.
7. Alfalfa roots must contain sufficient carbohydrates to survive low winter temperatures. Usually six weeks of growth in the fall are needed to allow time for the leaves to produce these carbohydrates. Consult Figure 20 for the date of the final cut in your area. Cutting no later than this date allows sufficient time to build up these carbohydrates before low fall temperatures stop food production.
8. Observing the fall rest period allows the alfalfa plant to store sufficient carbohydrates, **unless carbohydrate levels have been seriously lowered throughout the summer by frequent harvest.** Harvesting each cut all summer at bud or pre-bud stage will pull down the carbohydrate level so low that even the recommended fall rest period will not restore carbohydrate levels. To avoid this problem, allow second or third cuts to reach at least 25% bloom before harvesting.

WEED CONTROL IN FORAGES

In forages, annual weeds are the major problem during the seeding year. If not controlled, they can reduce stand thickness. After the seeding year, forage competition and harvesting usually controls these weeds.

Because most forage fields are left down for several years, perennial weeds have time to become well established and are dominant in years following seeding. Chemical weed control in forages is more complicated than in most other crops because forages are usually sown as a mixture of legumes and grasses. Herbicides are available that can be used without injury on legumes; others are safe to use on grasses; however, very few can be used without some injury in a mixture. Thus a program to control weeds prior to seeding forages and during the seeding year is necessary to prevent serious problems in later years.

Growing forage crops can assist in the control of some weeds. Three-cut programs will weaken some perennial weeds, such as milkweed. Poor competitors such as horsetail can be physically crowded by forage growth. Certain weeds, such as quackgrass, lambs-quarters and dandelions, can produce forage of reasonable quality, particularly if ensiled.

PREPLANT WEED CONTROL

It is almost impossible to remove most perennial weeds from established legume-grass forage stands. These weeds should be eliminated as much as possible prior to seeding. Taprooted weeds such as dandelions and chicory can be controlled by careful mouldboard plowing to bury the crowns. Weeds with underground creeping roots, such as bindweed, Canada thistle and quackgrass, are difficult to kill with tillage. They are best controlled by use of herbicides in the year prior to forage seeding.

Good weed control practices in grain crops will tend to keep the level of annual weed seeds in the soil under control and reduce the weed pressure in the forage seeding year. Annual weeds such as wild buckwheat and lady's thumb, often problems in forage seeding, are much easier to control in other crops than in a forage seeding.

Long-term pasture fields should not be plowed and seeded directly back to forages, as weed pressure can be heavy, and weed species unknown prior to seeding may become a problem.

WEED CONTROL IN THE SEEDING YEAR

In forage mixtures seeded under a cereal crop, a limited number of herbicides are available to control annual broadleaf weeds. Annual grass weeds are best controlled by seeding as early as the land can be worked. The companion grain crop also tends to suppress annual grasses.

Figure 21. Uncontrolled weeds are a major threat in direct seedings.

When forages are direct-seeded, weeds may be controlled by several methods. If weed pressure is relatively light and mainly annuals, harvesting the first cut as silage or hay removes the weeds. Where the broadleaf weed stand is heavy and can threaten forage establishment, a herbicide

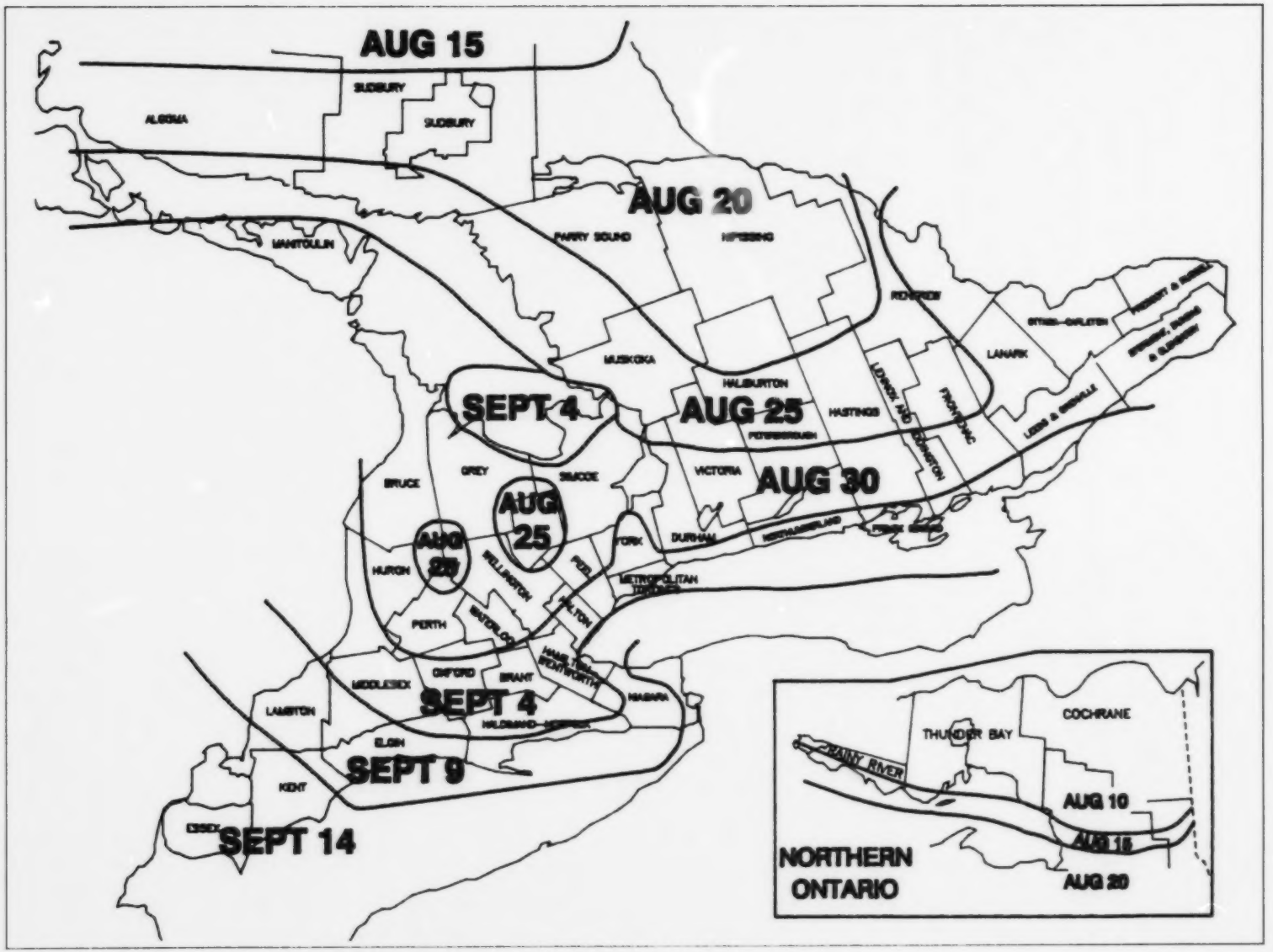

Figure 20. Start of the Critical Fall Harvest Period for Alfalfa.

To ensure persistence and succeeding yields, do not harvest alfalfa during a six-week period following the date shown on the map for each region.

should be used. Pay careful attention to proper rate and timing to avoid legume injury.

If the weed pressure is from annual grasses, there are preplant incorporated herbicides available that give excellent control. However, these herbicides can only be used when pure legume stands are being seeded.

Where annual grasses or broadleafs cannot be controlled with herbicides, clipping can suppress weed growth. Clip when the weeds are taller than alfalfa or clover, at a height of about 10 cm. Mowing too high encourages weeds to branch out and grow back, causing even more severe competition. Very low clipping removes too many of the alfalfa or clover leaves and can slow crop growth. Do not windrow the clipped weeds unless they are being removed from the field.

WEED CONTROL IN ESTABLISHED STANDS

In established forage stands, perennial weeds are the major problem. In a reasonably thick forage stand, annual weeds cannot compete. Pure legume stands are more likely to become infested with weeds than are legume-grass or grass stands. Grasses in the mixture cover the soil between legume plants and reduce establishment of weeds such as dandelions.

There are no satisfactory herbicides available to remove weeds from established legume-grass stands. In pure grass stands, many broadleaf weeds can be controlled with hormone-type herbicides.

The major weed in forage stands is dandelion. While this weed has reasonably good protein levels, it is low yielding and it seriously slows up the drying rate of windrows. Including grasses, particularly more aggressive species, in the forage mixture will help keep the dandelions in check. Use management practices that keep legume growth aggressive and competitive.

For information on herbicide use in forages, consult OMAF Publication 75, *Guide to Weed Control.*

FORAGE INSECTS

ALFALFA WEEVIL

The alfalfa weevil has not been a widespread problem in Ontario in recent years because the insect is being controlled by a fungal disease and several insect parasites. However, local outbreaks do occur from time to time which may require a change in timing of harvest or the use of insecticides. Damage will show first on shallow soils or on southerly slopes, particularly during warm springs.

Description and Life History

The adult weevil is a brown snout beetle, about 5 mm long, with a dark brown stripe extending from the head down the center of the back. Adults overwinter in trash, and emerge in spring to feed on new alfalfa growth and lay their eggs in alfalfa stems in May. Eggs may hatch in four days to three or four weeks, depending on the temperature.

Figure 22. Effect of alfalfa weevil feeding.

The young larvae crawl to the top of the alfalfa plant and feed in the folded leaves at the shoot tips where they are difficult to detect. As the larvae get larger, they feed on opened leaves and the entire field can take on a greyish-white appearance. The larger larvae are bright green with a black head and a distinctive white stripe down the center of the back. At full size, they are about 9 mm long. Larvae then form loosely woven white cocoons and enter the pupa stage, usually in late June or early July. Pupa hatch in one or two weeks into the adult stage. Adult feeding throughout the summer does not cause significant damage.

Control

Early weevil damage often coincides with the bud stage of alfalfa and the preferred method of control is cutting the alfalfa. If 25% of the stems show feeding damage in the tips, harvest the field as soon as possible.

Occasionally, warm May weather will result in an early hatch of weevil and feeding damage will show before it is practical to harvest the alfalfa. In those situations, an insecticide may be warranted and several insecticides are registered for weevil control; consult the current issue of OMAF Publication 296, *Field Crop Recommendations.* In deciding whether to use an insecticide, also consider that insecticides will kill the beneficial parasites and are very poisonous to bees present in the field, and that spraying operations will tramp some of the forage crop.

Occasionally, if weevil populations were high on a late first cut, surviving larvae will feed on the regrowth. Such feeding can eliminate alfalfa regrowth which may lead to a loss of the stand. If weevil feeding retards regrowth, an insecticide may be warranted.

ALFALFA BLOTCH LEAFMINER

During the early 1980s, the alfalfa blotch leafminer spread across southern Ontario. Evidence of feeding could be found in almost all fields and injury was often heavy, especially in second or third cut. In recent years, a parasite has controlled this insect and damage has dropped to insignificant levels in most fields. Local outbreaks are possible in the future, as parasite numbers fluctuate.

Description and Life History

The adult is a tiny black fly (under 2 mm long) which emerges in May from overwintering pupae on the ground. The fly lays one to three eggs in individual alfalfa leaflets. The eggs hatch into small maggots which feed on the green tissue between the upper and lower leaf "skin." The feeding shows up as whitish trails or blotches on the leaflets, often affecting 25 to 75% of the leaflet surface. When fully grown, the maggot cuts through the leaf skin, drops to the ground and pupates. The adult fly emerges in about a week and the cycle begins again. There are three generations of the leafminer per year.

Figure 23. Alfalfa blotch leafminer injury.

Damage

Leafminer feeding in itself does not result in significant yield loss. However, feeding may result in considerable leaf drop or leaf shattering during harvest, which in turn may reduce forage quality. This has only been a problem in second or third cut.

Control

Control by parasites is quite effective. Although adult leafminers can be controlled with an insecticide prior to egg laying, insecticide use is rarely justified. The treatment is not effective unless timing is good and it may not pay off in increased forage yield unless leaf drop is extensive. The parasite population, which has been giving good control, is also reduced by insecticide use.

POTATO LEAFHOPPER

The potato leafhopper causes more loss in alfalfa yield and quality in southern Ontario than any other insect. The first cut of established fields is not affected, but second and third cuts may be. Direct seedings are particularly vulnerable and seedings under grain may also be affected. Damage varies greatly from none to severe from year to year, and also with location in the province. Generally damage is greater in areas of higher heat units and in hot dry summers.

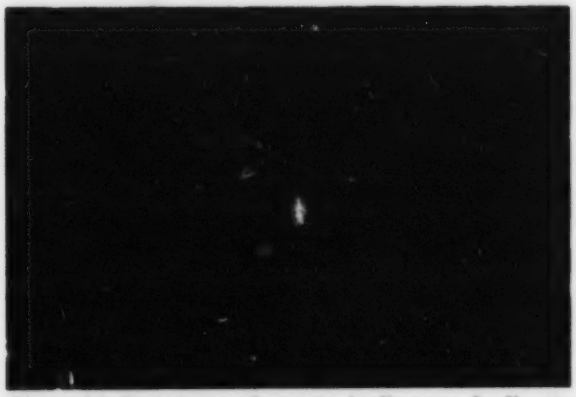

Figure 24. Symptoms of potato leafhopper feeding on alfalfa.

Description and Life History

The potato leafhopper adult is a pale green wedge-shaped insect which is only 3 mm long when fully grown. The immature stages (nymphs) are a yellow-green colour, even smaller than the adult and are usually found on the underside of a leaf. Because of their colour and small size, leafhoppers are very difficult to see when not moving. Often the jumping and flying activity of the adults can be detected as one walks in an alfalfa stand.

Leafhoppers do not survive the winter in Ontario. They overwinter in the southern United States and move north in the wind, arriving in Ontario in early June. Eggs are laid in the upper leaves and stems of alfalfa. The nymphs grow to the adult stage in about 25 days and there are three or four generations each year.

Damage

Leafhoppers insert their sucking mouthparts into the main vein of alfalfa leaflets and withdraw plant sap. This feeding blocks the flow of water and nutrients in the leaf, resulting in a yellow or bronze "V" shaped area towards the tip of the leaf. The leaves do not fall off the plant, but in heavily affected fields, the entire field will take on a yellow or bonze colour and the crop is usually stunted. Symptoms show up more when the crop is under drought stress.

Figure 25. Severe potato leafhopper "burn" on alfalfa.

Potato leaf hopper feeding reduces alfalfa yield because of the stunting and reduces protein content because of higher leaf loss during harvest. Reduced plant vigour, particularly on the seeding year, can lead to winterkill.

Control

To avoid forage losses, control measures must be taken **before** symptoms show up on the alfalfa. Spraying after the field becomes discoloured will kill leafhoppers, but alfalfa remains stunted. Because leafhoppers are small and difficult to detect, the only accurate way to assess leafhopper numbers is with an insect sweep net. Small alfalfa plants are more susceptible to injury, thus fewer leafhoppers can be tolerated with early growth. Use the following chart as a guideline for spraying (or harvesting if the crop is sufficiently mature).

Alfalfa Height (cm)	Average Number of Leafhoppers Per Sweep to Justify Control
8	.2 adults
15	.5 adults
25	1 adult or nymph
35	2 adults or nymphs

When spraying is warranted, consult OMAF Publication 296, *Field Crop Recommendations,* for information on registered insecticides.

ALFALFA SNOUT BEETLE

This insect is a native of Europe and was first discovered in Canada in 1986 near Prescott. Since the insects cannot fly and moves by walking from field to field, its spread has been slow. The insect is of concern because it has the potential to wipe out a stand of alfalfa.

Description and Life History

The adult snout beetle is a dark grey weevil, about 12 mm in length. It overwinters in the soil, emerges in April and lays eggs from mid-May through June. All the adults are female and capable of laying between 125 and 500 eggs. Eggs are laid near alfalfa crowns and hatch into creamy white legless grubs which feed on the alfalfa roots. Early feeding consumes the lateral roots. As the grubs get bigger, they attack the taproot by girdling and gouging the surface. Grubs feed until late fall, reaching a length of 13 mm, and then hibernate in the soil until spring. The entire second year is spent in the soil in the pupa and adult stages, with no feeding occuring during this year. When the adult emerges in April of the third year it feeds on alfalfa foliage and repeats the cycle.

Damage

Foliage feeding by adult snout beetles is not as serious as is root feeding by the larva stage. Larvae feeding causes alfalfa plants to wilt, turn yellow and die, particularly during late summer and fall when the taproot is attacked by the larger grubs. While alfalfa is preferred by alfalfa snout beetle, clovers and some weeds will also be attacked.

Control

To check for this insect, dig wilted plants and inspect roots for feeding damage and the presence of grubs. At present, there are no insecticides registered for use on alfalfa that will control this insect while it is in the soil.

Killing adults is not a very effective control, since two-thirds of the life cycle is spent in the soil and this is the stage that causes serious injury. No natural enemies are known to give significant control. To reduce populations, infested fields should be plowed and planted to corn, soybeans or cereals for two years.

EUROPEAN SKIPPER

This insect can occasionally cause serious injury to timothy stands, both in hay and seed production. Incidence tends to be higher in northern and eastern Ontario. Damage is caused by larvae leaf feeding.

Description and Life History

The adult is a small orange butterfly, with a wing span of 2.5 cm. The butterfly lays eggs between mid-June and mid-July on grasses, but the eggs do not hatch until the following spring. The larvae are light green caterpillars which are about 2 cm long when full grown. Caterpillars feed during May and early June, pupate for two weeks and then emerge as the adult butterfly between mid- and late June.

Damage

The caterpillar prefers timothy, but will feed on most of the grasses grown in Ontario. It rolls the grass leaf into a tube and eats the leaf from tip to base while hiding in the tube. Leaves will also be notched and gouged and under high populations, the leaves and head can be stripped.

Control

Fields should be checked for caterpillars in late April and May. Control is warranted if six caterpillars are found in an area 30 cm by 30 cm. When spraying is warranted, consult OMAF Publication 296, *Field Crop Recommendations,* for information on registered insecticides.

MEADOW SPITTLEBUG

This insect is best known by the white frothy spittle that protects the nymph stage. The yellowish-green nymph sucks plant juices from forage plants from within the protective spittle. Feeding causes some stunting and shortening of the internodes, particularly in alfalfa and mainly in the first cut. In early June, the nymph becomes a grey- to brown-coloured adult, about 6 mm long, which jumps quickly when disturbed. The adult causes no economic damage.

PEA APHIDS

Alphids are quite common in alfalfa and can buildup to quite large populations in midsummer, especially during cool, wet seasons. Aphids suck plant juices which can cause wilting and stunting. This insect is eaten by both adults and larvae of ladybird beetles, and by several other insects commonly found in forages. Heavy rains and very hot or cold weather also reduce infestation.

PLANT BUGS

The lygus bug, the tarnished plant bug and the alfalfa plant bug are commonly found in alfalfa fields in midsummer. They suck juices from foliage and can cause misshapen leaves. They also feed on flowers and seed pods. They are an economic problem when alfalfa is grown for seed and can seriously reduce seed yields.

VERTICILLIUM WILT

This fungus disease causes death of alfalfa plants mainly during the third and fourth production years, thereby leading to both reduced stands and yields. It is found throughout Ontario. Verticillium wilt tends to show up in more fields, and at higher levels, in years with cooler summer temperatures and higher rainfall.

Verticillium wilt plugs the "plumbing" of the alfalfa plant, thereby limiting water movement. Leaves on infected plants wilt, curl inwards and turn light brown and eventually dark brown. Infected plants are often stunted and 10 to 15 cm shorter than normal plants. Infection occurs to individual plants in the stand, rather than in concentrated patches.

Figure 26. Early symptoms of verticillium wilt.

Figure 27. Verticillium wilt symptoms in third-year alfalfa.

This disease is spread on infected plant material from older infected fields to younger fields by harvesting equipment, and in particular by mowers. Cutting infected fields last in each cutting cycle, and then cleaning leaves and stems from harvesting equipment, may reduce the spread to younger fields.

The disease can spread from farm to farm on infested harvesting equipment, or through the purchase of infested hay. Alfalfa seed fields are inspected for this disease and seed lots are tested. Certified seed is not considered to be significant means of spreading the disease.

If this disease is detected on a farm, resistant varieties should be planted. Consult OMAF Publication 296, *Field Crop Recommendations,* for the currently recommended alfalfa varieties and their rating for verticillium wilt resistance. Varieties of alfalfa are now rated as HR (highly resistant), R (resistant), MR (moderately resistant) and S (susceptible). Varieties with the R and HR resistance level appear to have third and fourth year stands with no evidence of the disease. Wilt will still appear in varieties with MR rating, although at lower levels than in susceptible varieties.

PHYTOPHTHORA ROOT ROT

This soil-borne alfalfa disease is present in most fields in Ontario. It usually only causes problems to alfalfa during the seeding year and under unusually wet conditions. The soil has to be saturated for 10 days or more for the disease to develop, which means it is a problem mainly on soils that have imperfect or poor drainage, or on clay loam soils in years that have periods of excessive rainfall.

Infected plants are stunted, and leaves turn yellow or reddish, wilt, and often drop. Lateral roots rot first and then the taproot, from the tip towards the soil surface. The rot may completely kill the plant or may leave the taproot only 2 to 10 cm long. Surviving plants are low yielding and much more susceptible to drought and winter heaving, due to the short taproot.

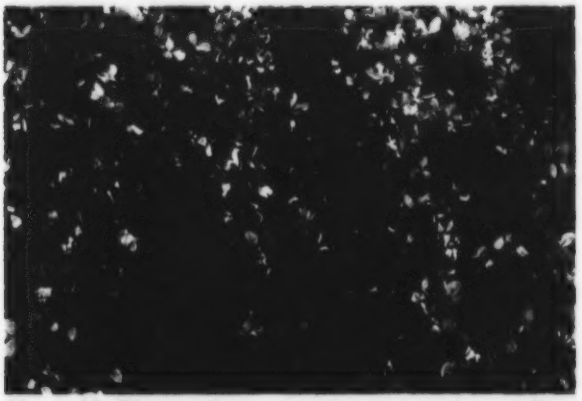

Figure 28. Phytophthora root rot symptoms in a seeding-year stand.

This disease can be greatly reduced or eliminated on many soil types by improving drainage. On clay loam soils, however, internal drainage can be so slow that tiling cannot adequately control the disease.

If drainage cannot be improved sufficiently to prevent seedling loss under excessive rainfall conditions, resistant varieties should be planted. Varieties range from S (susceptible) to HR (highly resistant). Varieties rated HR (highly resistant) give more protection than those rated R (resistant). Consult OMAF Publication 296, *Field Crop*

Recommendations, for the currently recommended alfalfa varieties and their resistance rating for phytophthora root rot.

Figure 29. Taproot rotting caused by phytophthora root rot.

BACTERIAL WILT

This is a major disease of alfalfa which can cause serious stand thinning in the second or third production years. The disease is rarely seen in Ontario because varieties susceptible to the disease have not been recommended since 1970. Most varieties sold in Ontario are rated R (resistant) or HR (highly resistant); disease symptoms have not been seen on varieties with either of these ratings. For information on the currently recommended alfalfa varieties and their rating for bacterial wilt resistance, consult OMAF Publication 296, *Field Crop Recommendations.* To continue to keep this disease out of alfalfa fields, susceptible varieties should not be planted.

LEAF SPOTS OF ALFALFA

Common, Lepto, Stemphylium and Bacterial Leaf Spot are leaf spot diseases caused by different organisms. They produce brown to black spots on alfalfa leaves, causing them to turn yellow and drop prematurely. The leaf spot diseases are usually most prevalent during moist weather conditions, from mid-July onward, and when alfalfa is allowed to become overmature.

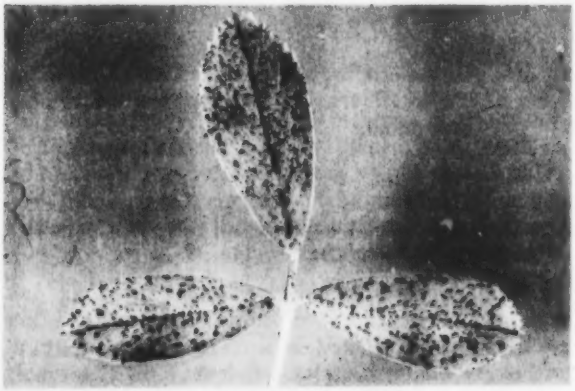

Figure 30. Common leaf spot on alfalfa.

These diseases may be partially controlled by cutting promptly once the desired cutting stage is reached.

CROWN AND ROOT ROTS OF ALFALFA

Crown and root rots can be caused by several disease organisms which enter the roots and crown through cracks and wounds. Brown dead areas will develop in the crown. With time the central core of the root may become dark brown or black, rotted and even hollow. Infected plants have reduced vigour and eventually die. Injury caused by machinery and livestock tramping is often responsible for allowing the rots to enter the plant. Avoid as much as possible operating machinery or grazing when the soil is wet. Since crowns that have heaved overwinter are more susceptible to mechanical injury, good drainage reduces root and crown rots.

Rots spread more quickly within alfalfa plants under stress. Good crop management practices, such as a good harvesting schedule, adequate soil fertility, control of insect and other diseases, will help to reduce the severity of root and crown rots.

SPRING BLACK STEM OF ALFALFA AND RED CLOVER

These diseases cause dark spots, irregular in shape, on the lower leaves. Spots enlarge and merge until much of the leaf is covered. Leaves then turn yellow and drop. Spots on the lower stem may enlarge until the lower portion of the stem becomes completely black. Small, young shoots at the base of the plant may be killed by the disease.

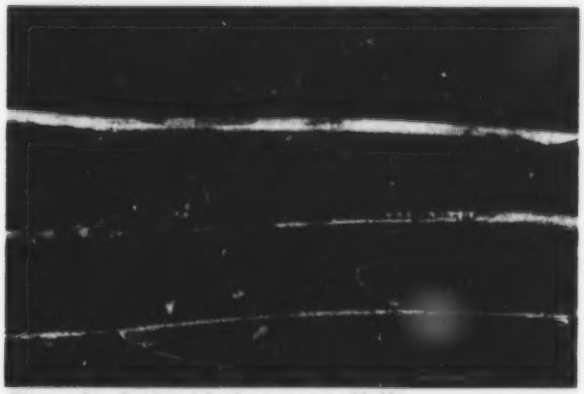

Figure 31. Spring black stem on alfalfa.

The disease is favoured by cool moist weather and is usually a problem only in the first cut. Control by cutting infected stands as soon as the stand is mature enough.

POWDERY MILDEW OF RED CLOVER

This disease results in a light grey powdery layer on the upper surface of red clover leaves. The leaves eventually turn yellow and brown. Severe infections lower the yield and quality of forage.

Powdery mildew is favoured by moderately dry weather and often is most severe in late summer and fall. Many newer varieties of red clover have resistance to the disease.

The type of livestock being fed defines the quality of forage you should be seeking. For a beef cow, the most appropriate hay is quite mature and therefore low in protein and digestibility. On the other hand, for a high-producing dairy cow, mature hay is inappropriate and quality hay which is high in protein and digestibility must be used. The remainder of this section will use the phrase high quality to mean hay high in protein and digestibility.

The timing of harvest is the most important consideration when trying to produce top-quality feed. If forage is cut at the wrong time, there is nothing you can do to change the quality of that forage.

All forage crops decline in feeding value as they mature. For instance alfalfa, once the buds appear, will decline about .2% per day in protein and about .4% per day in digestibility (Tables 4 and 5).

TABLE 4. Protein Content of Alfalfa and Bromegrass at Various Stages of Maturity

Stage of Maturity	Date	%Crude Protein	
		Alfalfa	Bromegrass
Medium bud	June 4	21.5	13.4
Early flower (heads emerged)	June 20	17.0	10.0
Full flower	June 30	16.2	6.7
Early seed	July 6	15.6	5.8

Fulkerson, OAC

TABLE 5. Digestibility of Alfalfa and Bromegrass at Various Stages of Maturity

Stage of Maturity	Date	% Digestibility	
		Alfalfa	Bromegrass
Medium bud	June 4	72.6	73.8
Early flower (heads emerged)	June 20	65.2	67.2
Full flower	June 30	62.1	60.6
Early seed	July 6	60.9	59.7

Fulkerson, OAC

Figure 32. Harvest at proper maturity gives maximum feed value.

The best time to cut forages for either hay or hay-crop silage is at the late bud to 1/10 bloom stage of the legumes or when the heads of the grasses have just emerged. Cutting at an earlier stage will result in higher quality feed, but will give reduced yields; delayed harvesting will give higher yields, but lower feed quality.

With a large acreage of forage, it is advisable to start cutting prior to 1/10 bloom to ensure the later cut material will still have adequate quality.

The greatest amount of feed value is stored when both field and storage losses are minimized. The amount of each loss is largely determined by the moisture content of the forage going into storage. Storing dry hay results in high field losses but relatively small storage losses. On the other hand, storing forages as hay-crop silage gives lower field losses but higher storage losses (Figure 33).

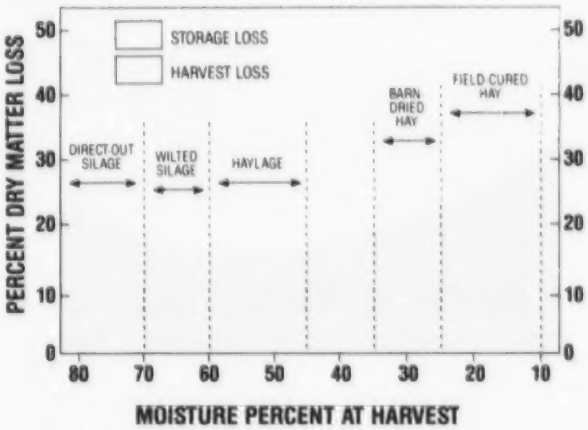

Figure 33. Estimated harvest and storage losses.

DRY HAY

There are a number of losses associated with the production of dry hay (less than 20% moisture). Many of these losses are in the form of the leaves, which contain about half of the dry matter and two-thirds of the protein (Table 6).

TABLE 6. Early Bud Vernal Alfalfa - First Cut - Guelph

Plant Fraction	Yield/ac	% CP	Yield CP
Leaves	2000	31.6	632
Stems	2150	13.8	296
Whole Plant	4150	22.3	928

Fulkerson, OAC

Respiration

Even after they are cut, forages continue to respire and consume sugars until the moisture content drops below 40%. Under relatively fast drying conditions these losses can be kept to a minimum: 2-8% of total dry matter. Under poor drying conditions (low temperature, high humidity, etc.) the plants take longer to dry down to 40% moisture and dry matter losses as high as 16% have been measured.

Weathering

Rainfall on windrowed hay sustains respiration and causes other losses — nutrients such as the simple sugars are leached from the leaves and leaf loss increases (Table 7).

TABLE 7. Effect of Rainfall on Leaf and Protein Percentages

Treatment	Leaf (%)	Protein (%)
No Rain	56.8	15.5
Rain at 48 hr*	53.5	18.7
Rain at 24 and 48 hr	45.6	18.2

**2.5 cm of rain were applied at each time.*

M. Collins, *Agronomy Journal,* Nov.-Dec. 1982

Because sugars are leached from the leaves, which results in less dilution, the percentage of protein increases. However, the amount of protein produced per acre is reduced and protein digestibility also decreases.

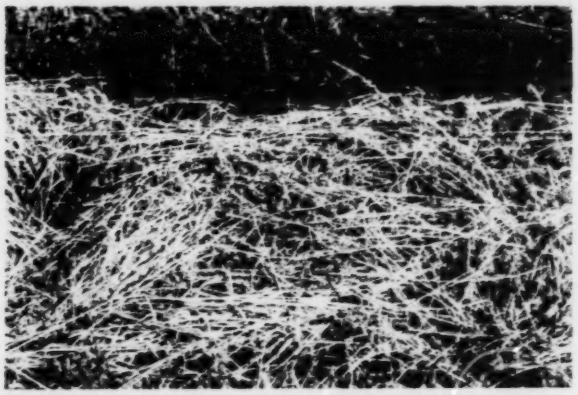

Figure 34. Rainfall on windrowed hay lowers quality.

Weathering decreases the amount of hay the animals will eat (Table 8).

TABLE 8. Effect of Weathering on Animal Intake of Early Bud Alfalfa

Treatment	Voluntary Intake (kg / 100 kg of animal body weight)
No rain	2.1
Rain*	1.7

**2.5 cm over a four-day period.*

Mechanical Losses

As forages cure, the leaves and small stems become more brittle. Any mechanical operation (e.g., raking or tedding) done on material having less than 40% moisture causes losses. The lower the moisture percentage, the greater the losses (Table 9).

Rake when hay is moist.

Figure 35. Raking dry swaths leads to excessive leaf loss.

TABLE 9. Amount of Leaf Loss at Various Moisture Levels

Moisture %	Leaf Loss %
50	5
30	10
20	20

O. Friesen, Am Soc. Agric. Eng. Publication I-78, 1978

Losses at the baler pickup and in the baling chamber can be reduced by raking light windrows together and by travelling at maximum ground speed. Baling losses with large round bales often exceed those experienced with small rectangular bales.

The losses from haymaking that have been reported in research trials are summarized in Table 10.

TABLE 10. Potential Haymaking Losses

Source of Losses	Loss of Dry Matter %
Respiration	2 - 16
Cut and Condition	2 - 5
Rake	5 - 25
Baling	
Small bales	3 - 8
Large bales	1 - 15
Transport	1 - 10
Total	10 - 71

Storage Losses

Hay which has less than 20% moisture and is stored under cover will normally experience storage losses of under 10%. These losses can normally be attributed to handling losses as the bales are moved.

Hay having over 20% moisture is at risk from spoilage due to the action of microorganisms metabolizing sugars in the hay and giving off heat. The final temperature reached by the hay is related to: (a) percentage of moisture in the hay; (b) density of the bale and how tightly they are packed in the mow; and (c) the temperature and humidity of the outside air.

Usually the first indication that hay may be getting hot is an odour similar to pipe tobacco and possibly steam rising from the mow. Mow temperature can be monitored by pushing a pointed probe, constructed of 1/2 inch copper tubing, into they hay and then lowering into it a candy thermometer on a string. Never take temperatures alone because fire pockets can develop and there is a risk of falling in.

The following are useful guidelines:

64°C Entering the danger zone. Take temperatures daily.

70°C Danger! Inspect every four hours to see if the temperature is rising.

80°C Fire pockets may be anticipated. Call the fire department and remove the hot material.

100°C Critical! In the presence of oxygen, ignition will take place.

If a thermometer is not available any rod or pipe pushed 2 m into the hay will give an indication of the hay's temperature. If you can hold onto the metal with bare hands once it is removed, then the temperature is below 65°C. If it is too hot to hold for even an instant, then it is over 80°C and the fire department should be called.

HAY ADDITIVES

Drying agents and hay preservatives are available which can help reduce the dry matter losses associated with making dry hay. They allow baling at a higher moisture or increase the rate of drying.

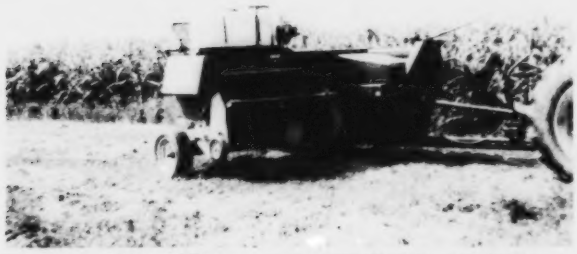

Figure 36. Hay additives can be applied during baling.

Drying Agents

Drying agents such as sodium and potassium carbonates are applied at the time of cutting and can reduce drying time up to a full day under ideal conditions. These chemicals disrupt the waxy layer on the stem which, under good drying conditions, increases the rate at which moisture can leave the plant. To get satisfactory results, the following rules should be observed: (a) apply to stands that are mainly legumes because they do not work on grasses; (b) use a minimum of 30 gallons water / acre to get good coverage of the cut forage; (c) lay the crop in a wide windrow, to expose as much of the hay as possible to the sun and drying winds.

Even with drying agents, the drying process is still dependent on the weather, requiring high temperatures and low humidity. This makes these agents less effective on the first cut than on the aftermath. In addition, treated windrows don't shed rainfall as well as untreated ones.

Hay Preservatives

Since the moisture content at baling determines the amount of preservative, it is important that moisture content be measured accurately. This is probably the weakest link in hay preservation. Generally moisture testers are not accurate enough to fine tune the amount of preservative needed. Even if an accurate method such as oven drying of a sample is used, there can be as much as 10-15% difference in the moisture content within a swath. This variation can lead to pockets of wet material that will be inadequately treated. To determine the range in moisture content, make a few bales and take samples from them rather than the swath.

There is a difference between average moisture content and maximum moisture content and when reading the labels of the various products, pay attention to the wording. Adjust the rate to maximum rather than average moisture content.

There are a number of products on the market that fall into one of three categories:

(a) ORGANIC ACIDS

Mixtures of propionic plus other organic acids when used at the right concentration (Table 11) will allow safe baling at higher moisture without heating damage. The buffered mixtures now being sold have a pH of approximately 6.0 and do not remove paint nor irritate the skin and eyes as the older products did.

These propionic-based products can be successfully used if the following rules are observed: (a) use the correct rate which is determined by the moisture content of the hay (Table 12); (b) do not mix treated and untreated bales in the mow because the moisture could migrate from the treated to untreated and result in spoilage.

TABLE 11. Effect of Organic Acids on Hay Preservation

Treatment	Maximum Temperature	Dry Weight Loss (%)	Digestible Dry Matter
Control	124	15.1	60.4
.02% propionic acid	127	16.7	61.8
.2% propionic acid	115	13.2	62.2
.5% propionic acid	104	11.7	61.0
1.0% propionic acid	86	7.6	65.0

W.R. Knapp, Agronomy Journal, 1976

TABLE 12. Recommended Rates for Applying Organic Acid Preservatives to Hay

Hay Moisture Level (%)	lbs of actual acid / ton hay
20 - 25	10
26 - 30	20
31 - 35	30

C. Sheaffer and N. Martin. U. of Minn.

There are products on the market that contain diluted quantities of propionic acid plus ingredients such as anti-oxidants or flavouring agents. These products are less costly than mixtures containing much higher amounts of organic acids, but research trials have shown them to be ineffective.

(b) ANHYDROUS AMMONIA

Anhydrous ammonia is a preservative that will increase the crude protein content and digestibility of poor hay. The recommended rate of application is 1% of dry hay weight and the hay not wetter than 30% moisture. The hay should be covered with plastic to retain the ammonia, otherwise the preservative effect is only temporary.

As a preservative, it is not as good as the organic acids and should not be used on high quality hay. Its use on high quality hay has caused "crazy cow" syndrome wherein animals run wildly into obstacles, go into convulsions and possibly die. High quality ammoniated hay should not be fed to animals with a high nutritional demand such as lactating cows.

(c) BACTERIAL INOCULANTS

Two types of inoculants are available for use on baled hay:

- silage inoculants, containing lactobacillus species
- hay inoculants, containing various bacteria (depending on the product)

Silage inoculants are not effective on hay because there is not enough moisture in hay (25% moisture or less) to support lactobacillus growth. Nor do they function effectively in the presence of air.

There is limited evidence that hay inoculants may reduce heating in baled hay, and result in greener colour and less dust. When using these products, pay careful attention to the recommended maximum moisture level in both square and round bales.

HAY-CROP SILAGE

Storing forage as hay-crop silage has some advantages over storing it as hay. These include: (a) lower harvest losses; (b) lower labour costs because all operations can be mechanized; (c) less dependence on good drying conditions, thereby allowing the crop to be cut at the desired maturity.

When forage is first put into a silo, conditions are aerobic (air is present in the silage mass). Aerobic bacteria produce some heat as they breakdown carbohydrates and sugars into carbon dioxide and water and use up the trapped oxygen.

When the air has been consumed, the silage becomes anaerobic (free of oxygen) and this promotes the growth of anaerobic bacteria. These organisms convert the carbohydrates and sugars to organic acids which preserve the silage. In addition, some of the protein is broken down into amino acids, ammonia and other non-protein nitrogen compounds. During this ensiling process, the acids lower the pH, while the production of ammonia tends to raise it. The production of ammonia increases the amount of time it takes to reach a stable pH.

In two or three weeks, the silage reaches a stable pH of 4.5 to 5.0 and all bacterial and enzymatic activity stops. Once this stable pH has been reached further breakdown of nutrients and spoilage are prevented and the silage will keep for extended periods of time, provided air is excluded.

STORAGE LOSSES

Five types of storage losses can occur in silos. In most cases they are associated with oxygen trapped in the silage mass:

1. **Respiration losses.** When plants are harvested and ensiled the plant cells continue to breath, resulting in a breakdown of sugars and other carbohydrates.
2. **Fermentation losses.** An extended period of anaerobic bacteria activity results in an excessive breakdown of sugars.
3. **Surface spoilage.** Less compacted silage at the top of the silo spoils because it is continuously exposed to the air.
4. **Heating.** Heating causes plant sugars and proteins to combine and form indigestible compounds. This results in a "toasting" or browning of the silage (Table 13). In extreme cases, because the silage is too dry or a continuous supply of air is getting into the silage, spontaneous combustion can lead to a fire. Such fires can happen at any time of the year and are almost impossible to extinguish.
5. **Seepage losses.** When excessively wet material (over 70% moisture) is put into a silo, the weight of the material squeezes moisture from the silage at the bottom. The seepage carries sugars and other nutrients out of the silo. In addition, seepage can lead to excessive corrosion of the silo walls, reinforcing rods and the possible collapse of the silo.

TABLE 13. Protein Digestibility (%) As Affected by Temperature and Length of Storage

Heating Period Temperature (Days)	Protein Digestibility %		
	43°C	57°C	71°C
0	69.7	69.7	69.7
9	68.4	64.4	50.0
30	65.4	49.0	30.1

When a silo is opened to remove feed, there can be further losses in feed value. These losses are caused by moulds and yeasts that become active in the silage when it is exposed to air. Losses can occur at the cut face of the silage mass or in the bunk while being fed.

MANAGEMENT PRACTICES

Several management practices can be used to reduce losses in hay-crop silage:

a. **Use the proper length of cut.** Fine chopping helps to exclude air by allowing tighter packing. A 1/4 to 3/8 inch theoretical cut is desirable with 65% moisture silage and is an absolute necessity with moisture levels lower than 60%. The length of cut is probably most critical with horizontal silos, although it is still important with upright and sealed silos. Harvester blades must be sharp and correctly set and worn ledgerbars replaced. Chopping finer than 1/4 inch is undesirable because it doesn't improve packing but does require more horsepower and will result in depressed butterfat production when fed to dairy cows.

b. **Store the hay-crop silage at the proper moisture content.** For conventional upright silos, the ideal moisture content is 60 to 65%, although in larger silos it may be as low as 55%. For horizontal silos, the silage should be stored at a higher moisture content to ensure good packing and air exclusion. The correct moisture content for oxygen-limiting silos is 40 to 55%.

   If the silage becomes too dry, cut fresh material and continue to fill the silo by alternating fresh and dry loads. The addition of water to increase the moisture of dry silage does not work because: (1) the water is not absorbed by the silage and can easily runoff; and (2) a garden hose doesn't deliver enough water to make an appreciable difference in moisture content.

c. **Provide a tight silo.** A silo will act as a chimney. If air can get in, it will move up through the silage mass which could lead to spoilage, heating of the silage and in extreme cases, fire. Cracks in the silo walls or around the doors should be caulked or reconditioned to prevent the entry of air.

d. **Distribute material evenly within the silo.** Without good distribution, the lighter material will collect along the wall, thereby leading to poor packing.

e. **Fill the silo rapidly and continuously if possible.** In a upright silo, the silage is not compacted until a considerable depth of material has been put in the silo. The top part of the silage will be less dense and hold more air which could cause heating and loss of quality. If filling is delayed for a few days, the silage should be covered with plastic to reduce the chance of spoilage.

f. **Seal the silo.**
   1. In sealed silos, the hatches should be closed at night and during interruptions in filling. When filling is complete, the hatches should be closed immediately.
   2. In conventional silos, the silage should be levelled and covered with plastic, weighted down by a few centimetres of silage. The silage should remain covered for 5 to 10 days before feeding. After this period, the chance of serious heating damage and dry matter losses will be greatly reduced.
   3. Horizontal silos should be filled by completely filling one end and then working towards the other end to minimize the surface area exposed to air. As the silo is filled, it should be packed in relatively thin layers to get good air exclusion.

      Sealing with plastic is essential in horizontal silos. The plastic should be held firmly in place. Old tires placed closely together work very well. The plastic should not be allowed to flap in the wind; this acts as a bellows and pumps air into the silage rather than excluding it.

g. **When feeding remove about 7 cm of silage per day.** This removal rate will reduce the amount of spoilage at the face of the silage.

SILAGE INOCULANTS

The application of a bacterial silage inoculant to alfalfa forage at 50 to 65% moisture often increases the rate of fermentation and lowers the final pH of the silage. This can improve silage quality and increase dry matter recovery. Application of an inoculant may reduce the breakdown of plant proteins. In addition, bunk life, animal intake and animal performance may be improved.

Bacterial silage inoculants usually contain *Lactobacillus plantarum* (a lactic acid producer) alone or in combination with other bacterial species. The product should supply at least 100,000 live bacteria (cfu or colony forming units) per gram of forage when applied at the recommended rates. Products applied in the liquid form are often more effective than dry powders.

The application of a bacterial silage inoculant will not overcome the effects of poor silage management or poor weather conditions. These products are most effective when applied to top quality forage under top management.

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